World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

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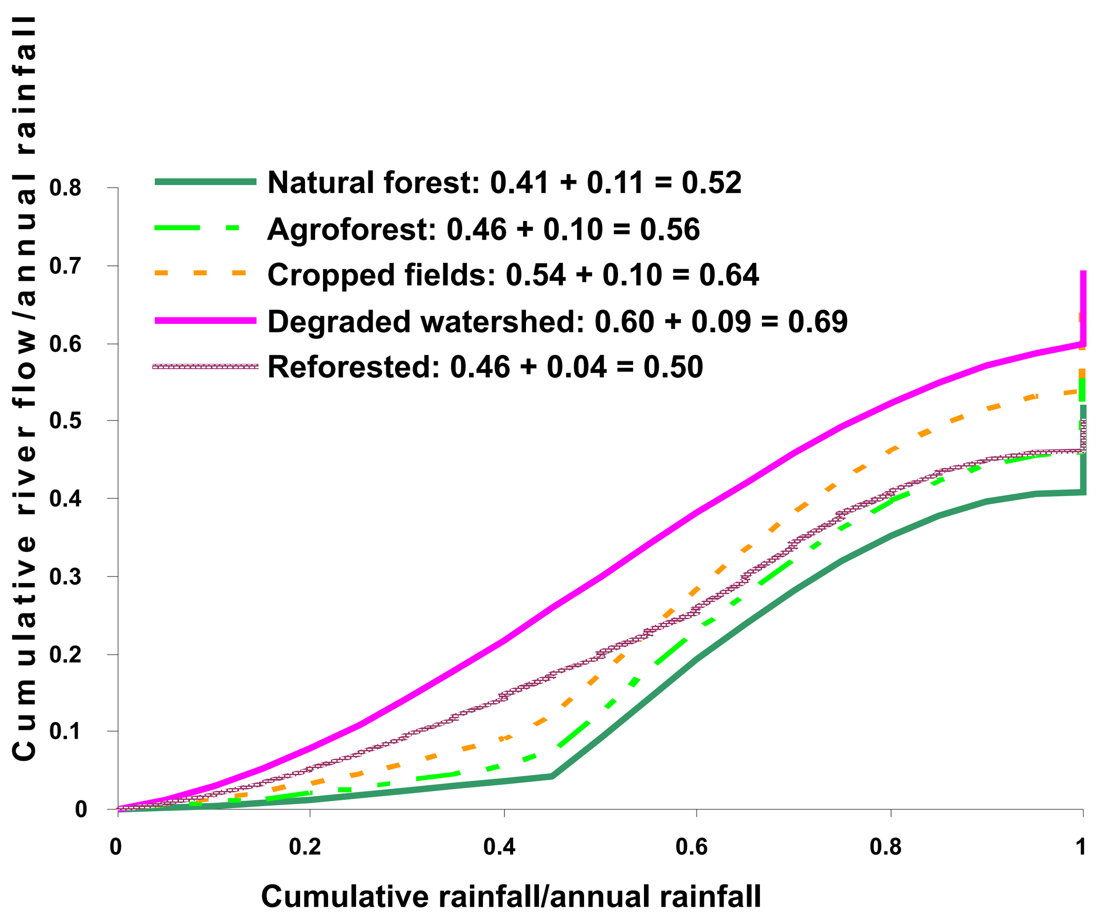
Rainfall & Discharge Relationship:
A Simple technique to diagnose the health of a watershed

Introduction

Floods and droughts tend to be attributed to 'deforestation' in the public debate, but they may also be a reflection of 'climate change'. Real change in the hydrological response of a watershed to actual rainfall may be due to: 1) changes in interception and water use by the vegetation, 2) soil compaction shifting 'interflow' to 'overland flow', 3) soil degradation that reduces the recharge of groundwater reserves and associated dry season flows and/or 4) changes in the water storage capacity of the landscape. There are different implications for downstream water users and for possible corrective actions. But so far the diagnostic tools are limited. We tested a simple technique to analyze data on cumulative river flow (discharge) in relation to cumulative rainfall and applied it to data sets from catchments that experienced large shifts in forest cover, in different climatic zones.

The principles

The three basic pathways for water to reach the river are 1) directly by overlandflow (within minutes of the rainfall event), 2) through 'Interflow' or 'Soilquickflow' (usually within one day) and via (deep) groundwater flows, taking longer time. After a dry period the landscape has 'storage capacity' for water. If the landscape becomes saturated with water, all incoming water is passed on to the river. If we see a break in the relationship between rainfall and discharge we can conclude that this saturation point is reached.



Cumulative dry season flows reflect storage capacity of the landscape

Example of a simple 'null-model', responsive to rainfall patterns, PET, storage capacity and infiltration properties

Figure 1. Examples of the relationship between rainfall and river flow, expressed as mm (or l/m2) in cumulative form during a hydrological year (from start to end of the rains), for different conditions of surface infiltration.

Changes in total water use by the vegetation affect the annual discharge per unit rainfall

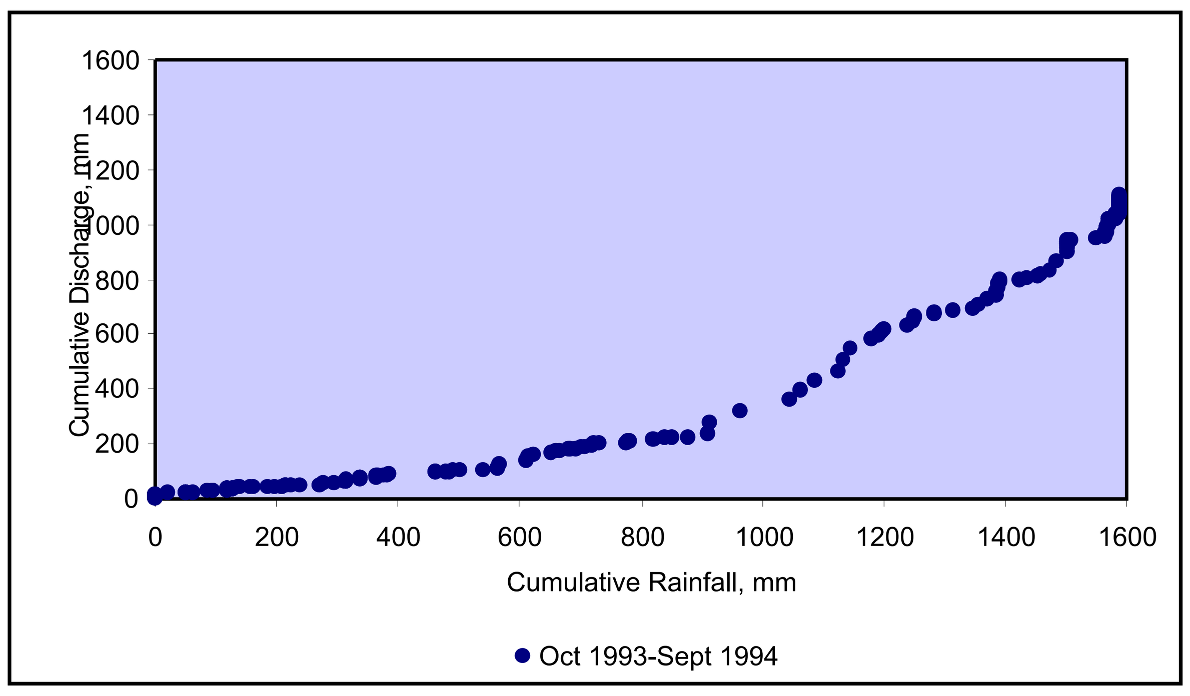
If soil compaction is the primary 'degradation' process, the sharper peaks in the hydrograph after a break point' in the line which indicate the storage limited during rainy season.

If surface compaction is the primary issue, high runoff is expected at any part of the rainy season, without differentiation during rainy season

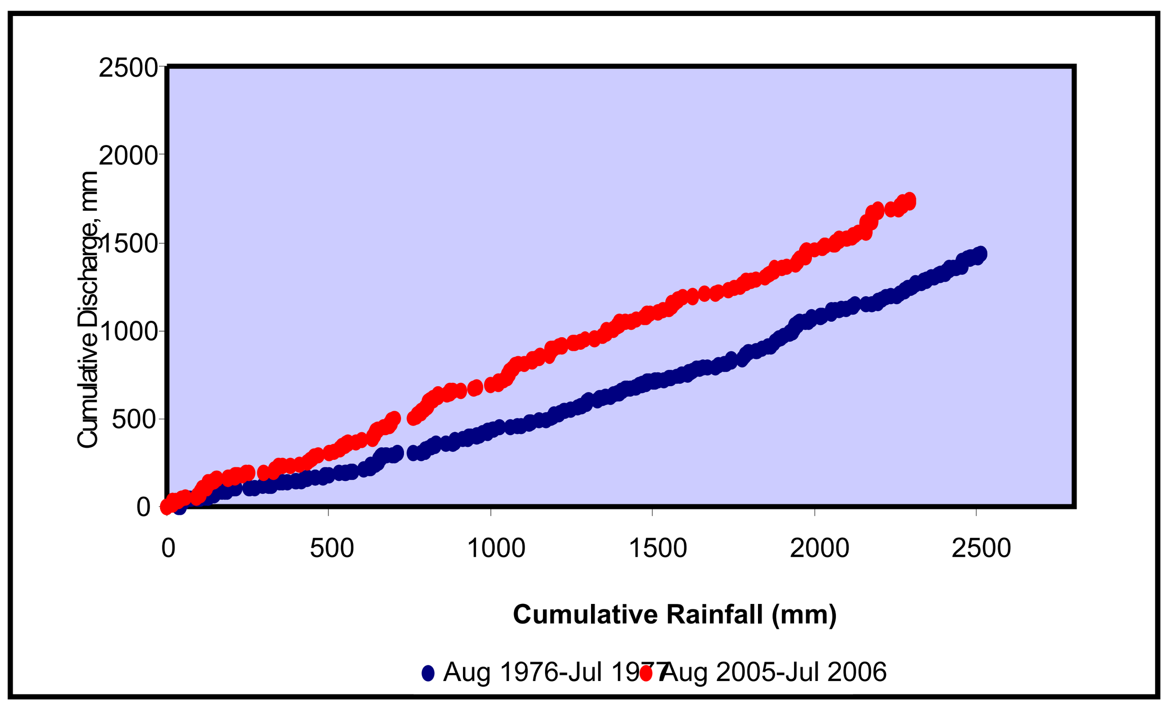
The Technique

1. Records of daily river flow during at least one full hydrological year and daily rainfall records for the same year, derived from the catchment
2. List rainfall and river flow in a spreadsheet for all days of the year. For an absolute interpretation of the discharge fraction, river flow data will have to be related to the catchment area and expressed in mm/day, as are rainfall data;
3. Derive a cumulative form of the rainfall and riverflow data, and construct a graph as shown in figure1
4. Plot another years of data, to detect the change of river flow compare with the previous years

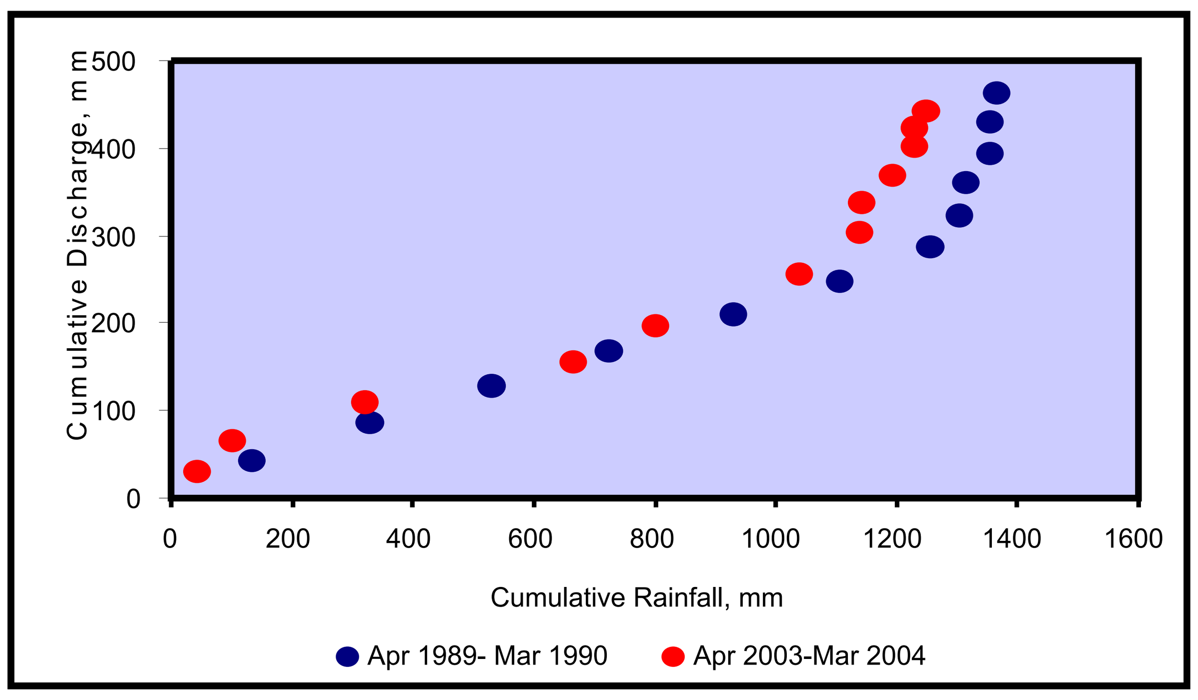
Examples Application -- analysis is in progress… Comments are welcome!!



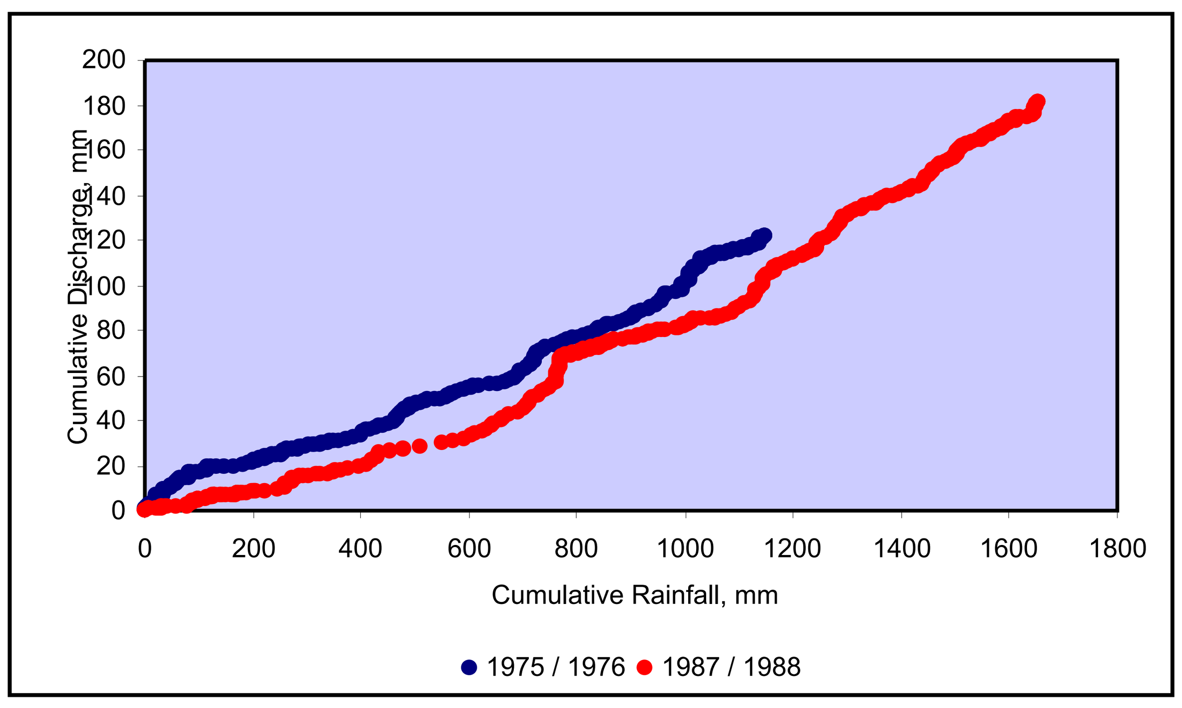
1. MotaBuik Watershed Indonesia 100 km^2, Water Storage Capacity is reached at 1000 mm



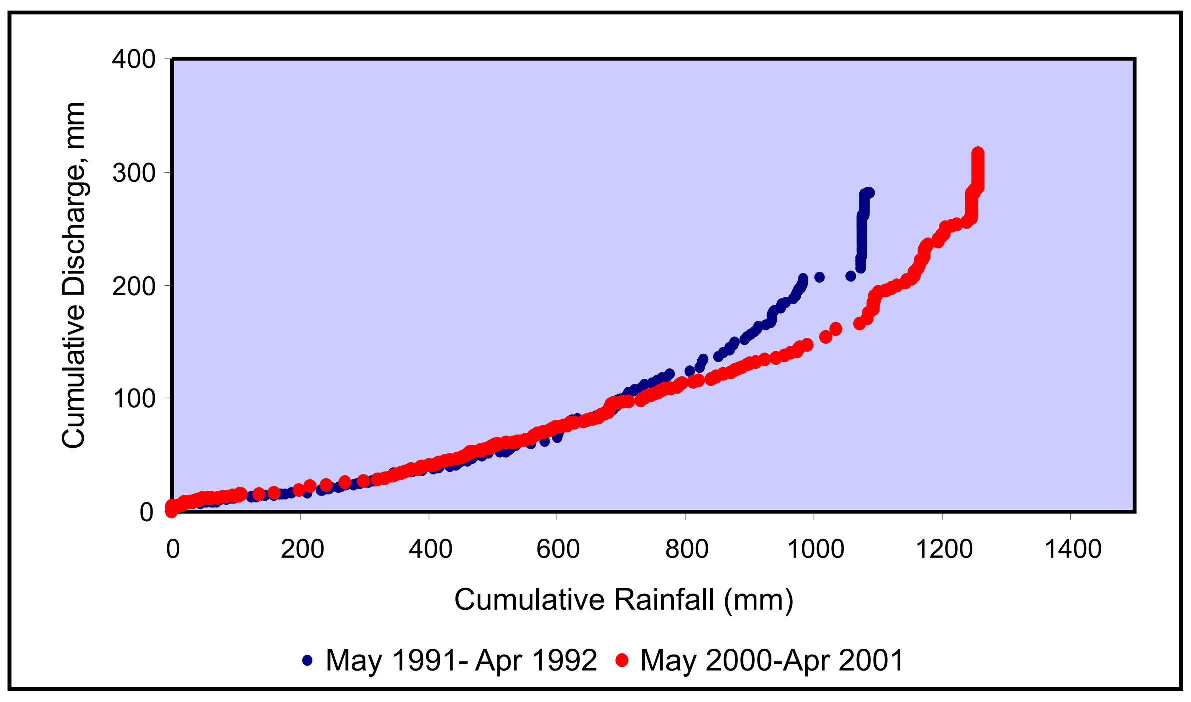
2. Way Besai Watershed Indonesia 400 km^2, Decreased forest cover leads to higher w.yield



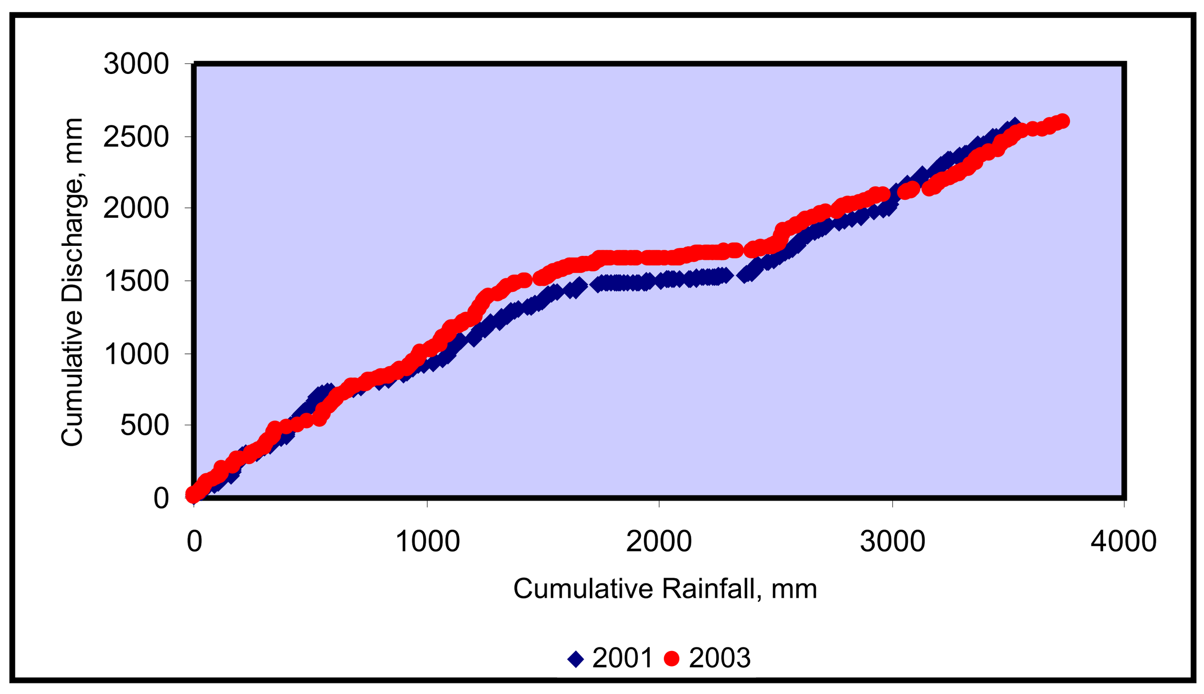
3. Manupali Watershed Philippines 500 km^2, Watershed still has a good condition



4. Nyando Basin Kenya, 970 km^2 Full storage capacity is not reached



5. Mae Chaem Basin Thailand, 3740 km^2, Watershed still has a good condition



6. Kapuas Hulu Basin Indonesia, 9000 km^2, Watershed still has a good condition